

CONFLICTING CHRONOMETRIC DATA FROM THREE PREHISTORIC SITES IN CONTRA COSTA COUNTY, CALIFORNIA

PAUL D. ZIMMER
WILLIAM SELF ASSOCIATES, INC.

This report discusses a comparative study conducted as part of the Los Vaqueros Reservoir Expansion project, where the age of cultural deposits at three prehistoric sites was determined using both obsidian hydration analysis and radiocarbon dating. Where possible, the charcoal samples and obsidian artifacts submitted for analysis were selected from identical contexts in order to provide control to the study. In all cases, the results revealed a large discrepancy between the date ranges established by the two techniques. This presentation provides possible explanations to account for the lack of correlation between the data sets, and offers suggestions for future research.

As part of Section 106 mitigation for the Los Vaqueros Reservoir Expansion project in Contra Costa County, California, archaeologists with William Self Associates, Inc. (WSA) conducted excavations at three previously identified sites within the Los Vaqueros watershed on behalf of the Contra Costa Water District and the U.S. Department of the Interior Bureau of Reclamation. As part of the mitigation for that expansion project, CA-CCO-09, CCO-397, and CCO-450/H were subjected to a Phase I investigation designed to define site boundaries, determine cultural components, and establish a reliable chronology for each site. This paper will focus on the preliminary results of the chronological studies conducted as part of those investigations, and will examine in particular discrepancies found between dates established by obsidian hydration analysis and those from radiocarbon dating. The following sections will include a presentation of data derived from the investigation, a discussion of potential causes for the observed chronometric conflicts, and suggestions for future research.

PREVIOUS INVESTIGATIONS IN THE LOS VAQUEROS WATERSHED

The Los Vaqueros watershed has been subject to archaeological scrutiny since the 1960s, when researchers from San Francisco State College (now San Francisco State University) recorded the numerous outcrops of bedrock mortars that characterize many of the local sites. Further cultural resources inventories were conducted in the 1980s in anticipation of reservoir construction (Bramlette 1989), while Phase I and Phase II excavations relating to Section 106 mitigation for that project were performed in the 1990s (Meyer and Rosenthal 1997; Praetzellis et al. 1995; Sonoma State University Academic Foundation 1992; Zeising 1996, 1997).

Of particular relevance to the current study were a series of investigations conducted by Sonoma State University from 1994 to 1996 (Meyer and Rosenthal 1997). In their analysis of eight prehistoric sites, they identified problems with obsidian hydration dating in the watershed, noting that in several of the sites hydration dates directly contradicted radiocarbon analysis, shell bead sequences, paleoethnobotanical profiles, and geoarchaeological indicators. The most telling passage from the summary report, concerning CCO-696, states that

the obsidian hydration results...were primarily at odds with the other temporal indicators. In the absence of evidence for physical mixing between...the paleosols, the obsidian associations seem to be good. Due to the strength of the other chronological information, it appears that the majority of the hydration readings do not accurately reflect the age of the deposit [Meyer and Rosenthal 1997:III.66].

The data produced by the 1997 study suggested that there is a fundamental issue with the application of hydration dating in the watershed. With this in mind, the chronological studies conducted by WSA sought

Table 1. Radiocarbon data.

SITE #	LAB #	CONTEXT	$^{14}\text{C} \pm \sigma$ YRS. B.P. $\Delta^{13}\text{C}$ -CORRECTED	$\Sigma^{13}\text{C}$	CAL YRS. $\pm 2\sigma$
CCO-450/H	Beta-308278	CU2, Level 7	2090 \pm 40	--	200-30 B.C., 30-20 B.C., 10 B.C.-A.D. 1
	Beta-316267	CU1, Level 12	3850 \pm 30	-24.4 o/oo	2460-2200 B.C.
	Beta-316268	CU8, Level 6	3490 \pm 30	-24.6 o/oo	1890-1740 B.C.
	Beta-316269	Below Feature 1	1730 \pm 30	-26.4 o/oo	A.D. 240-390
CCO-09	Beta-318996	CU D0, Level 3	180 \pm 30	-25.2 o/oo	A.D. 1650-1690, 1730-1810, 1840-1840, 1850-1860, 1860-1870, 1920- post 1950
	Beta-318997	Feature 9	1770 \pm 30	-25.0 o/oo	A.D. 180-190, 210-340
	Beta-318998	Feature 14	200 \pm 30	-25.1 o/oo	A.D. 1650-1680, 1730-1810, 1930-post 1950
	Beta-318999	Feature 32	70 \pm 30	-25.7 o/oo	A.D. 1690- 1730, 1810-1920; post 1950
	Beta-319000	Feature 24	1830 \pm 30	-25.7 o/oo	A.D. 90-100, 120-250
CCO-397	Beta-308274	CU18, Level 11	130 \pm 30	-25.4 o/oo	A.D. 1670-1780, 1800-1900, 1900-1940, 1950- post 1950
	Beta-308275	CU19, Level 2	90 \pm 30	-25.0 o/oo	A.D. 1680-1730, 1810-1930, post 1950
	Beta-308276	Within Feature 22	320 \pm 30	-25.1 o/oo	A.D. 1470-1650
	Beta-319001	CU7, Level 7	850 \pm 30	-25.1 o/oo	A.D. 1160-1260
	Beta-319002	CU 13, Level 3	170 \pm 30	-24.8 o/oo	A.D. 1660-1700, 1720-1820, 1830-1880, 1920-post 1950
	Beta-319003	CU 19, Level 3	90 \pm 30	-24.2 o/oo	A.D. 1680-1730, 1810-1930, post 1950
	Beta-319004	CU 13, Level 11	120 \pm 30	-22.3 o/oo	A.D. 1670-1780, 1800-1940, post 1950
	Beta-319005	CU 18, Level 13	550 \pm 30	-25.1 o/oo	A.D. 1320-1350, 1390-1430

not only to develop a robust dataset to clarify chronology at the sites under study, but also to test the efficacy of obsidian hydration dating at those locations.

CURRENT STUDY

In the current investigation, cultural deposits at CCO-09, CCO-397, and CCO-450/H were dated using a combination of radiocarbon and obsidian hydration data (Tables 1-2), with other chronological indicators used to supplement those data. Where possible, obsidian artifacts submitted for analysis were selected from associated contexts with established radiocarbon dates, creating a total of 16 directly comparable date sets across the three sites. What follows is an examination of each of those sites in detail.

CCO-09

CCO-09, located on the banks of Kellogg Creek south of the reservoir, is a bedrock mortar site with subsurface deposits consisting of fire-affected sandstone hearth features and associated occupational midden. Cultural deposits were dated through radiocarbon dating of in situ charred plant remains and hydration dating of obsidian artifacts. Chronometric data at CCO-09 were directly comparable in five unique contexts, including four intact fire-affected hearth features and one controlled excavation unit.

As shown in Table 3, radiocarbon analysis of charred botanicals recovered from Features 9 and 24 on the north side of Kellogg Creek produced dates of 1770 cal B.P. and 1830 cal B.P., respectively,

Table 2. Hydration data.

SITE	UNIT #	LEVEL	TYPE	WEIGHT (g)	MAX LENGTH (mm)	CUT LOCATION	SOURCE	EHT-ADJUSTED HYDRATION BAND
CCO-397	CU 7	7	Simple interior flake	< 0.1	5.3	Proximal	Napa Valley	Diffuse hydration
	CU 13	3	Simple interior flake	0.4	15.6	Distal	Napa Valley	2.2 μ
		11	Simple interior flake	< 0.1	7.1	Proximal	Napa Valley	1.9 μ
	Feature 22	n/a	Biface	3.8	25.1	Margin	Bodie Hills	6.2 μ
	CU 18	11	Edge-damaged flake tool	0.4	7.6	Margin	Bodie Hills	4.8 μ
		13	Simple interior flake	< 0.1	5.7	Medial	Napa Valley	Diffuse hydration
	CU 19	2	2nd decortication flake	0.1	10.6	Margin	Napa Valley	2.0 μ
3		Simple interior flake	0.2	12.5	Proximal	Napa Valley	2.1 μ	
CCO-09	D0	3	Biface fragment	0.1	6.8	Margin	Napa Valley	3.2 μ
	Feature 9	Within feature	Complex interior flake	0.3	10.2	Distal	Napa Valley	2.8 μ
	Feature 24	Within feature	Simple pressure flake	< 0.1	7.1	Proximal	Napa Valley	4.0 μ
	Feature 14	Within feature	Simple interior flake	0.6	17.1	Distal	Napa Valley	4.0 μ
	Feature 32	Within feature	Simple interior flake	0.1	9.7	Distal	Bodie Hills	3.7 μ
Biface			2	26.4	Margin	Napa Valley	3.3 μ	
CCO-450/H	CU 1	12	Simple interior flake	< 0.1	5.0	Medial	Casa Diablo	2.8 μ
	CU 2	7	Biface thinning flake	0.3	15.5	Distal	Napa Valley	3.2 μ
	CU 8	6	Simple interior flake	0.2	11.8	Distal	Napa Valley	4.5 μ
	Feature 1	Below feature	Biface thinning flake	0.9	27.5	Margin	Napa Valley	1.5 μ

Table 3. Results of chronometric studies at CCO-09.

CONTEXT	¹⁴ C ±σ YRS. B.P.	HYDRATION AGE	DIFFERENCE (¹⁴ C AGE MINUS HYDRATION AGE)
Feature 9	1770 ±30	1203 B.P. (rim 1)	--
		811 B.P. (rim 2)	+ 959
Feature 24	1830 ±30	2454 B.P.	- 624
Control Unit D0	180 ±30	1571 B.P.	- 1,391
Feature 14	200 ±30	221 B.P.	- 21
Feature 32	70 ±30	2100 B.P. (sample 1)	- 2,030
		1671 B.P. (sample 2)	- 1,601

Table 4. Results of chronometric studies at CCO-397.

CONTEXT	DEPTH	¹⁴ C ±σ YRS. B.P.	HYDRATION AGE	DIFFERENCE (¹⁴ C AGE MINUS HYDRATION AGE)
CU 7	--	850 ±30	--	--
CU 13	Level 3	170 ±30	742 B.P.	- 572
	Level 11	120 ±30	554 B.P.	- 434
CU 18	Level 11	130 ±30	3534 B.P.	- 3404
	Level 13	550 ±30	--	--
CU 19	--	90 ±30 (sample 1)	614 B.P.	- 524
		90 ±30 (sample 2)	676 B.P.	- 586
Feature 22	--	320 ±30	5897 B.P.	- 5577

suggesting a Middle-period occupation in that part of the site. However, hydration dates taken from those same contexts contradict those data, with obsidian from Feature 9 returning a date approximately 1,000 years younger than the radiocarbon, and obsidian from Feature 24 returning a date approximately 600 years older than its paired charcoal sample.

The data recovered from hearth features located on the south side of Kellogg Creek present a different picture than the Middle-period occupation suggested by the north bank features. Radiocarbon analysis of Features 14 and 32 returned dates of about 200 cal B.P. and 70 cal B.P., suggesting a very recent Late-period occupation in that part of the site. While the obsidian hydration date from Feature 14 presented the only example of concordance with radiocarbon at the site (and indeed the entire study), the hydration dates from Feature 32 indicate a disparity of more than 1,600 years. A similar result was obtained in Control Unit D0, where radiocarbon returned a date about 180 cal B.P., while obsidian suggests 1571 B.P.

Attempting to account for the disagreement between the hydration dates and other chronological indicators at CCO-09 is problematic. Factors such as stratigraphic mixing, artifact use and discard, and issues with the hydration dating method itself need to be considered and are examined in a detailed discussion below.

CCO-397

CCO-397 consists of an outcrop of bedrock mortars adjacent to Kellogg Creek with subsurface fire-affected sandstone hearth features and associated midden deposits. Radiocarbon and obsidian hydration analyses were used to establish site chronology, while temporally diagnostic flaked stone tools recovered during excavation supplemented those data.

As shown in Table 4, radiocarbon analysis of charred botanicals from Control Units 13, 17, 18, and 19 and Feature 22 all pointed to an occupation occurring after 500 cal B.P., which is correlated by artifact typologies. Four Stockton Expanded Stem and two Stockton Notched Leaf bifaces were recovered from the site, which is indicative of the Late period (Justice 2002). The results of the obsidian analysis present a more complicated picture. Taken at face value, the hydration dates suggest two occupation periods, with the more recent occurring from 500 to 700 cal B.P. and the earlier from 3500 to 5500 cal B.P. While the 500-700 B.P. range can arguably support the Late-period occupation as suggested by the other indicators, the lack of correspondence between the context-specific obsidian and hydration pairs is troubling. Even more problematic are the hydration dates from CU 18 and Feature 22, which suggest an Early-period occupation that is in no way supported by other evidence.

Table 5. Results of chronometric studies at CCO-450/H.

CONTEXT	LEVEL	¹⁴ C ±σ YRS. B.P.	HYDRATION AGE	DIFFERENCE (¹⁴ C AGE MINUS HYDRATION AGE)
CU 1	Level 12	3850 ±30	1203 B.P.	+ 2647
CU 2	Level 7	2090 ±40	1571 B.P.	+ 519
CU 8	Level 6	3490 ±30	1037 B.P.	+ 2453
Feature 1	Below Feature	1730 ±30	345 B.P.	+ 1385

A further complication is noted in the data from CU 17, where both radiocarbon and obsidian analyses suggest stratigraphic mixing, with shallower levels producing older dates than the deeper strata in both date sets. In fact, CCO-397 is riddled with ancient krotovina and currently active animal burrows even in the deepest portions of the site, suggesting chronic disturbance of cultural soils.

CCO-450/H

CCO-450/H is a multicomponent site located on the eastern slope of the Black Hills that features prehistoric, historic, and modern elements. Test trenching and unit excavation revealed an extensive prehistoric occupation, consisting of portable bedrock mortars, fire-affected hearth features, burials, and associated occupational debris. Radiocarbon and obsidian hydration dates were derived from six controlled excavation units and four features.

Broadly, the results of the radiocarbon analysis detailed in Table 5 suggest human occupations spanning the past 4,000 years. In particular, radiocarbon dating of charred botanicals from associated CUs 1 and 8 returned dates of approximately 3850 cal B.P. and 3490 cal B.P., representing the oldest cultural areas in the site. In contrast, the hydration dates derived from those contexts suggest a more recent occupation, with CU 1 obsidian returning an average date of about 1200 B.P., while obsidian from CU 8 returned an average of about 1720 B.P.

Radiocarbon dates derived from charred botanicals and in situ charcoal returned dates of approximately 2090 cal B.P. for CU 2, 1730 cal B.P. for Feature 1, and 1630 cal B.P. for Feature 3, placing those contexts within the Middle period. The radiocarbon dates are supported by paleoethnobotanical data, where those discrete components contained nut and berry assemblages dominated by acorn and bay, along with a more diverse small seed collection, that is representative of Middle-period sites (Wohlgemuth 2012). Hydration results from those same contexts provide contradictory information, however. Multiple artifacts from CU 2 suggest a date range of 676 to 1571 B.P., while Feature 1 returned a date range of 345 to 1203 B.P., representing a 1,000-year disparity.

DISCUSSION

In total, 15 out of 16 obsidian hydration dates do not correspond to their paired radiocarbon samples, with an average disparity of 1,500 years. Considering that this study is still ongoing and new data being produced, it would be premature to draw any hard conclusions from the initial results. Nevertheless, it is worthwhile to consider some of the factors that could be contributing to the lack of correlation found in the data, and to offer suggestions for future research.

Considering the shallow nature of many of the site deposits, it is reasonable to posit that some stratigraphic mixing has occurred through biological and geological processes. In the case of CCO-397, for example, the extensive burrowing identified throughout the site provided highly visible evidence of postdepositional disturbances. However, even the relatively intact cultural features identified at CCO-09 and CCO-450/H would have suffered prolonged erosion while exposed on the original ground surface, and once buried by subsequent sediments, would have been subject to bioturbation as well as continuing

physical and chemical weathering. In fact, geoarchaeological studies performed by Jack Meyer (Meyer 1996; Meyer and Rosenthal 1997) point out that the relative stability of landforms in the Los Vaqueros region has not readily allowed the archaeological record to develop a vertical structure, and cultural deposits spanning thousands of years could potentially exist on the same soil surface. By developing a more thorough understanding of stratigraphy at these sites, it may be possible to quantify the amount of disturbance present and correct for those factors in the chronological study.

It is also important to consider cultural practices as the means by which the artifacts were deposited in temporally distinct soils, in particular the reuse, curation, and scavenging of obsidian. Considering the scarcity and utility of obsidian as a tool source in Los Vaqueros, it is not unreasonable to assume that stocks of the material would be valued as a commodity as well as exploited to the point of exhaustion. Thus, ceremonial artifacts may have passed down through the generations, and old debitage scatters may have been repurposed as a supply for flake tools. These practices provide a vector by which those artifacts could have been deposited in more recent strata and accordingly produce conflicting chronological information.

Another factor to consider is that the hydration dates may not actually reflect the age of the artifacts under study. The problems associated with using obsidian hydration as an absolute dating method have been identified since the technique's inception (Anovitz et al. 1999; Friedman and Smith, 1960; Ridings 1996) and are related to establishing the hydration history of an artifact by considering the intrinsic water content of the source obsidian, the sample's burial depth, paleoenvironmental factors, and postdepositional processes. What is more, understanding how these factors change over the entire lifetime of an artifact is crucial in extrapolating its hydration history.

Correcting for local temperature variations, altitude, and burial depth can generate an "effective hydration temperature" (EHT) that attempts to collapse the varying historical conditions to which an artifact may have been exposed into a single value. The technique used to determine the EHT for this study was developed by Alexander Rogers and has proven successful at other sites in California (Origer 2012; Rogers 2006). However, the disparity between obsidian and radiocarbon documented in Los Vaqueros may suggest that hydration models in the watershed need to be revised and appropriate corrections made to EHT values and hydration rates.

Finally, even if an accurate EHT is calculated for an artifact, the measurement of the hydration rim can present an additional source of error. While thin-section microscopy is the traditional method used for hydration measurements, some researchers have identified problems with optical measurements that could give a false date (Anovitz et al. 1999). Newer techniques such as secondary ion mass spectrometry (SIMS) (Liritzis and Diakostamatiou 2002; Riciputi et al. 2002) claim to be more accurate at measuring the hydration rim than the optical method; however SIMS has not yet been adopted on a wide scale for archaeological hydration studies. Reanalyzing the hydration rims used in this study with SIMS could help verify or disconfirm the values used to calculate the dates found in this study.

SUMMARY

The results of the preliminary chronometric studies at CCO-09, CCO-397, and CCO-450/H indicate that there is a limitation in using the existing hydration models in the Los Vaqueros watershed. Considering the previously established problems associated with obsidian hydration use and the contradictory data produced by this investigation, the utility of hydration dating for sites within the Los Vaqueros watershed is understandably called into question. This has implications far beyond the scope of this study, however, as previous occurrences of hydration may need to be reevaluated, calling into question not only individual site dates but also regional histories based on those chronologies.

ACKNOWLEDGMENTS

I owe a large debt to Dr. Heather Price, who not only designed and directed the research project of which this study was a small part, but who has also provided immeasurable guidance and support throughout. I also wish to thank Kari Lentz for organizing the Emerging Voices in California Archaeology Symposium, and everyone who took part in our discussions. Finally, I would like to thank the Contra Costa Water District and the U.S. Department of the Interior Bureau of Reclamation for their ongoing support of archaeological research in the Los Vaqueros Watershed.

REFERENCES CITED

- Anovitz, Lawrence M., J. Michael Elam, Lee R. Riciputi, and David R. Cole
1999 The Failure of Obsidian Hydration Dating: Sources, Implications, and New Directions. *Journal of Archaeological Science* 26:735–752.
- Bramlette, Allen G.
1989 Phased Archaeological Research within the Los Vaqueros Locality, Contra Costa and Alameda Counties. *Proceedings of the Society for California Archaeology* 2:113-124.
- Friedman, Irving, and Robert L. Smith
1960 A New Dating Method Using Obsidian: Part I, the Development of the Method. *American Antiquity* 25:476–522.
- Justice, Noel D.
2002 *Stone Age Spear and Arrow Points of California and the Great Basin*. Indiana University Press, Bloomington.
- Liritzis, Ioannis, and Maria Diakostamatiou
2002 Towards a New Method of Obsidian Hydration Dating with Secondary Ion Mass Spectrometry via a Surface Saturation Layer Approach. *Mediterranean Archaeology and Archaeometry* 2(1):3-20.
- Meyer, Jack
1996 *Geoarchaeological Implications of Holocene Landscape Evolution in the Los Vaqueros Area of Eastern Contra Costa County, California*. On file at the Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Meyer, Jack, and Jeffrey S. Rosenthal
1997 *Archaeological and Geoarchaeological Investigations at Eight Prehistoric Sites in the Los Vaqueros Reservoir Area, Contra Costa County, California*. Anthropological Studies Center, Sonoma State University Academic Foundation, Rohnert Park, California. Submitted to the Contra Costa Water District, Concord, California. On file at the Northwest Information Center, Sonoma State University, Rohnert Park.
- Origer, Tom
2012 Obsidian hydration findings for CCO-09, CCO-397 and CCO-450/H. Letter reports produced for William Self Associates, Inc., Orinda, California.
- Praetzellis, Mary, Grace Ziesing, Jack McIlroy, and Adrian Praetzellis
1995 *Investigations at Three Historic Archaeological Sites, Summer 1993, for the Los Vaqueros Project, Alameda and Contra Costa Counties, California*. On file at the Northwest Information Center, Sonoma State University, Rohnert Park, California.
- Riciputi, Lee R., J. Michael Elam, Lawrence M. Anovitz, and David R. Cole
2002 Obsidian Diffusion Dating by Secondary Ion Mass Spectrometry: A Test Using Results from Mount 65, Chalco, Mexico. *Journal of Archaeological Science* 29:1055-1075.
- Ridings, Rosanna
1996 Where in the World Does Obsidian Hydration Work? *American Antiquity* 61:136-148.

Rogers, Alexander K.

- 2006 An Improved Method for Computing Effective Hydration Temperature of Obsidian. *Society for California Archaeology Newsletter* 40(2):35-41.

Sonoma State University Academic Foundation

- 1992 *Evaluation, Request for Determination of Eligibility, and Effect for the Los Vaqueros Project, Alameda and Contra Costa Counties, California*. Anthropological Studies Center, Sonoma State University Academic Foundation, Inc., Rohnert Park, California. Prepared for Contra Costa Water District, Concord, California.

Wohlgemuth, Eric

- 2012 *Letter Report: Results of Paleoethnobotanical Analysis for CA-CCO-450*. Far Western Anthropological Research Group, Davis, California

Ziesing, Grace H.

- 1996 *Investigations of Three Historic Archaeological Sites, CA-CCO-447/H, CA-CCO-445H, and CA-CCO-427H, for the Los Vaqueros project, Alameda and Contra Costa Counties, California*. On file at the Northwest Information Center, Sonoma State University, Rohnert Park, California.
- 1997 *Archaeological Investigations for the Vasco Adobe Site, CA-CCO-470H, for the Los Vaqueros project, Alameda and Contra Costa Counties, California*. On file at the Northwest Information Center, Sonoma State University, Rohnert Park, California.